GFDL Climate Variations and Prediction Group Research Summary

Improved Seasonal Prediction of Temperature and Precipitation over Land in a High-resolution GFDL Climate Model

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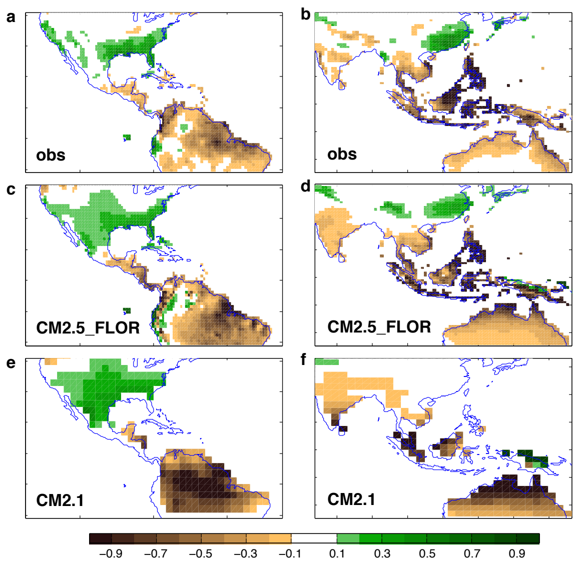
Skillful seasonal predictions of surface temperature and precipitation over land are in particular demand due to their influences on societal factors (such as agriculture, the energy sector and transportation) and ecosystems. Therefore, understanding and predicting future year-to-year of temperature and precipitation is central to NOAA's mission and highly relevant to society. This study demonstrates skillful seasonal prediction of near-surface air temperature and precipitation over land using a new high-resolution climate model (GFDL-FLOR) developed at NOAA-GFDL, and diagnoses the sources of the prediction skill.

The principal results of this study are that:

1) The new high-resolution GFDL FLOR model shows improved representation of precipitation and surface air temperature, and skillful seasonal predictions of near-surface air temperature and precipitation over land.



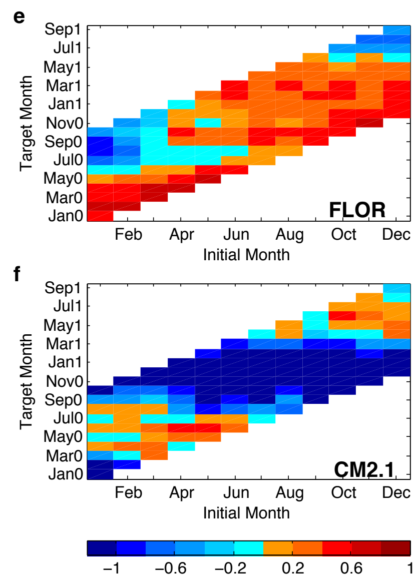


Figure 1: High-resolution GFDL-FLOR (middle panels) improves representation of observed (upper panels) connections between land precipitation and the El Niño-Southern Oscillation (ENSO) phenomenon, compared to its predecessor model (CM2.1, lower panels). Adapted from Jia et al. (2014)

Figure 2: Prediction skill for seasonal precipitation anomalies tied to ENSO, measured using SESS – with which a perfect prediction has a value of 1 and values greater than zero indicate skill. The new high-resolution GFDL-FLOR (upper panel) is generally higher than for its predecessor model (CM2.1, lower panel). Adapted from Jia et al. (2014).

2) The skill in seasonal precipitation over land arises primarily from the El Niño-Southern Oscillation (ENSO) phenomenon.

3) Both a multi-decadal change (in part from external forcing) component and a spatially heterogenous ENSO-related component contribute to the seasonal prediction skill of near surface air temperature over land.

4) Reconstructing predictions by filtering out unpredictable components in the model improves seasonal skill compared to raw predictions from model.

This study shows that the use of refined statistical analysis and a high-resolution dynamical models leads to significant skill in seasonal predictions of near-surface air temperature and precipitation over land. Output from predictions with GFDL-FLOR is being made available to the NWS (and world) through the North American Multi-Model Ensemble for Seasonal Prediction (NMME).

The development of GFDL-FLOR, which has also resulted in fundamental enhancements in the ability to predict seasonal TC activity (Vecchi et al. 2014), was enabled by years of climate research and model development at GFDL – including the breakthrough high-resolution modeling efforts of Delworth et al. (2012), Zhao et al. (2009) and Chen and Lin (2013), and the seasonal to decadal prediction efforts (*e.g.,* Zhang and Rosati 2010; Yang *et al.* 2013). Enhancements to NOAA's research supercomputing capability including access to Gaea at the Oakridge National Laboratory made this work possible.

The authors employ a statistical optimization approach to identify the most predictable components of seasonal temperature and precipitation over land. The two most predictable components of near-surface air temperature are characterized by a spatially homogeneous component that is mostly due to changes in external radiative forcing in both boreal winter and summer, and a spatially heterogenous ENSO-related pattern in boreal winter. The most predictable components of precipitation in boreal winter and summer are also ENSO-related. These predictable components of temperature and precipitation show significant correlation skill for all leads from 0 to 9 months. Importantly, the reconstructed predictions based only on the leading few predictable components from the model show considerably better skill relative to observations than raw model predictions.

Manuscripts available:
Jia, L. and coauthors (2014): Improved Seasonal Prediction Skill of Land Temperature and Precipitation in a GFDL High-Resolution Climate Model, *J. Climate (submitted).*
http://www.gfdl.noaa.gov/cms-filesystem-action/user_files/gav/publications/jetal_14_flor_tsandpr.pdf

Vecchi, G.A., T. Delworth, R. Gudgel, S. Kapnick, A. Rosati, A.T. Wittenberg, F. Zeng, W. Anderson, V. Balaji, K. Dixon, L. Jia, H.-S. Kim, L. Krishnamurthy, R. Msadek, W.F. Stern, S.D. Underwood, G. Villarini, X. Yang, S. Zhang (2014): On the Seasonal Forecasting to Regional Tropical Cyclone Activity. J. Climate (submitted).
http://www.gfdl.noaa.gov/cms-filesystem-action/user_files/gav/publications/vetal_14_flor_tcs.pdf